Offshore Structure

The present invention relates to offshore structures such as for example, relocatable oil production platforms.

It is known in the art to provide offshore structures for use in oil production having a base, a number of legs and a platform which are pre-assembled before the entire structure is then transported to the production site. However, the transportation and installation of such structures is extremely costly and time consuming so that they are not easily relocatable.

Therefore it has been proposed in the art to provide offshore platforms in which a jacking system is used to lower the base to the seabed and to raise the platform to the required height above the base. Thus, ideally the deck or platform may be easily lowered and the base may be easily raised so that the entire structure can then be moved to a new site. Such platforms have a plurality of legs, a base and a platform and a rack and pinion type of jacking device has been used to raise and lower the base and platform as required. The rack and pinion provides a guide for the base and platform as they are being raised and lowered and also can be locked off so as to hold the platform at the required height while the rig is in use.

However, the jacking equipment required for such decks is expensive to produce and, in addition, as it remains permanently attached to the deck, it requires regular maintenance which is also extremely costly. Thus, if it were possible to remove the jacking system from the structure after installation, substantial savings could be made.

The present invention therefore seeks to provide an improsed offshore structure in which a jacking system is not used to hold up the deck.

Therefore, from a first aspect, the present invention provides an offshore structure comprising a base, a deck and a plurality of legs extending between the base and the deck, wherein the legs are arranged outboard of deck and a connection is provided between an inwardly facing face of each said leg and the deck.

By providing legs located outboard of the platform, the deck may be raised to the required height relatively easily. Also, the formation of the connection between the legs and the deck allows the jacking system easily to be removed after installation. Thus, a standard jacking system can be hired for the duration of the installation of the structure, avoiding the manufacturing and maintenance costs involved with the permanent jacking systems of the prior art.

Preferably the deck is formed so that it does not include recesses for the legs. Preferably the deck is generally rectangular.

Most preferably the jacking system provided to raise the deck is also arranged entirely outside the line of the deck.

The legs could take any known form, for example tubular or, more preferably a lattice, for example a lattice made up of angle sections. Preferably each lattice leg comprises a vertically extending chord at each corner thereof. Still more preferably, each chord is circular in cross-section.

Further, the lattice leg may be of any shape which satisfies the design requirements for a particular structure. However, preferably the lattice leg is triangular.

The connection between each leg and the deck could be formed in any suitable manner. Preferably, the connection between each leg and the deck comprises a shear plate attached substantially vertically between the platform and a leg chord.

In certain design situations, the chord of the leg

could be of sufficient strength for the required loading. However, preferably the connection further comprises a stiffening plate extending through a diameter of the tubular member, wherein a first end of the shear plate is welded to the stiffening plate and the shear plate and the stiffening plate are substantially aligned.

This provides a relatively simple means of connecting the shear plate to the tubular member and also provides extra strength in the structure.

In the event that the base of the structure was lying level on the seabed, the deck could be raised to the same height on each of the legs of the structure. However, in order to provide tolerances in the level of the deck relative to the legs, thus allowing for different seabed conditions, the stiffening plate preferably extends over a greater length of the chord than the length of shear plate.

Thus, the shear plate need not be accurately aligned in the vertical direction before being welded to the stiffening plate.

Preferably, tolerance in the distance between the inboard end of the shear plate and the deck edge is also accommodated. Thus, preferably the inboard end of the shear plate is welded between two plates extending outwardly from the deck edge.

Preferably, the shear plate as described above carries only the shear forces between the platform and the legs. Therefore, the connection preferably further comprises at least one further coupling plate attached horizontally between the deck and the leg chords. This plate may carry tensile and compressive forces and bending moment loading applied between the deck and the legs.

The coupling plate could be attached to the tubular chord and the deck in any suitable manner. Preferably however, the coupling plate has a cut-out in its end

facing the leg chord, such that a part of the periphery of the leg chord is received within the cut-out. More preferably still, the cut-out is elliptical in shape. Therefore, a degree of tolerance in angular misalignment of the platform relative to the tubular leg is provided.

Although the coupling plate may be attached to the deck in any suitable manner, it is desirable that the plate be relatively simple to connect to the deck on-site. Preferably therefore, a horizontal web is attached to the deck and the coupling plate is butt welded thereto.

The coupling plate could be designed so as to be of sufficient strength itself to carry the necessary loading. However, preferably plate stiffeners extending from the inboard end to the outboard end and most preferably across the deck web are provided in the coupling plate. Still more preferably, a coupling plate is provided both at the top and the bottom of the shear plate.

Although it may be possible to attach the plates together in various ways, each coupling plate is preferably welded to the shear plate at the join between the plates.

Although a single connection could be provided between each of the legs and the deck, in a preferred embodiment of the invention, the connection is formed between the deck and two leg chords located at either end of the inwardly facing face of the lattice legs. Such an arrangement allows a stable connection to be formed between each leg and the deck.

In addition to the structure described above, a method of installing an offshore platform having some of the above described features is believed to be novel and inventive in its own right. Therefore, from a second aspect, the present invention provides a method of installing an offshore structure comprising a base, a deck and a plurality of legs located outboard of the

deck, the method comprising the steps of: jacking the deck to the required height; forming a permanent connection between the deck and the legs; and removing the jacking system from the structure.

As the legs of the structure are located entirely outboard of the deck, the deck may be jacked up the leg relatively easily without a high risk of it becoming obstructed. In addition, the removal of the jacking system allows the installation of the structure to be carried out at a significantly reduced cost.

Also, the jacking mechanism is also preferably entirely located outside the line of the deck.

Although as stated above, the deck would be unlikely to become obstructed when being jacked up the legs, guides are preferably provided on the deck so as to guide the deck as it is jacked up the leg. Thus, in severe wave and wind conditions as are often found on site, the deck is hindered from moving excessively relative to the legs. However, guides may not be necessary depending on the size of the platform, water depth and other factors.

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~~There will be many possible ways of assembling the base, deck, legs and guides relative to one another prior to installation of the platform. However, preferably, the method of installing the offshore structure further comprises the steps of: attaching four legs to the base; attaching two guides to the deck; floating the deck over the base so that it passes between the legs until the guides engage two of said legs; and attaching two guides to the deck.~~

~~Thus two guides are installed after the deck has been floated into position so that they do not interfere with the positioning of the deck.~~

Preferably, the guides comprise beams attached to and projecting from the deck and being shaped for engaging a chord of a said leg.

Preferably, the deck is located relative to the

legs prior to formation of the permanent connection. This allows some elements of the permanent connection to be prefabricated as their approximate dimensions will be known. In addition, as the deck cannot move relative to the legs once it has been located, the permanent connection is easier to make.

Preferably, the deck is located by pulling the leg towards the deck so as to hold a leg chord against the guide. Still more preferably, a hydraulic tugger is provided between an outer edge of the leg and the deck so as to pull the leg towards the deck.

In the method described above, the legs might skew slightly when the hydraulic tugger is tightened. This is because, the leg chord adjacent the guide would be held in position so that the other leg chord adjacent the deck would continue to be pulled towards the deck, effectively pivoting the leg about the guide. Therefore, hydraulic screw jacks are preferably provided at the base of the platform so as to push the inboard leg chords away from the lower deck edge, thus locating the leg squarely adjacent the deck edge.

Each of the legs could be located relative to the deck one by one and the permanent connection formed after each leg was located. However, preferably, the deck is pulled towards each of the legs simultaneously. This allows the location of the deck relative to the legs to be adjusted so as to provide a relatively even gap between each of the legs and the deck.

The method of locating a deck of an offshore structure relative to a plurality of outboard lattice legs is further considered to be novel and inventive in its own right. Therefore, according to a third aspect, the present invention provides a method of locating a deck of an offshore structure relative to a plurality of outboard lattice legs, said legs comprising a plurality of chords arranged at respective corners thereof, said method comprising the steps of pulling an outer leg

chord towards said deck and pushing the leg chords located adjacent the deck away therefrom.

Preferably, the outer leg chord is pulled towards the deck by means of a hydraulic tugger.

Still more preferably, the leg chords located adjacent the deck are pushed away therefrom by means of hydraulic screw jacks extending from the deck edge.

When installing the offshore structure, the permanent connection could be made by any suitable means. However, preferably, the permanent connection is formed by welding a substantially vertically extending shear plate between a chord of the lattice leg and the deck edge. Still more preferably, a stiffening plate is provided through a diameter of the leg chord, and a first side edge of said shear plate is welded to said stiffening plate, and said shear plate and said stiffening plate are substantially aligned.

In order to allow for tolerance in the vertical level of the deck relative to the leg, the stiffening plate preferably extends over a greater length of the leg chord than the length of the shear plate.

In order to provide tolerance in the horizontal dimensions of the gap between the deck edge and the inboard edge of the stiffening plate, two plates are preferably welded to the deck edge on respective sides of the shear plate and extending outwardly from the deck edge, and the inboard end of the said shear plate is preferably welded between the two plates.

Preferably, the shear plate carries shear forces only such that the web plate does not have to line up precisely with the bulkhead of the deck. Therefore, the connection further preferably comprises a further coupling plate attached horizontally between the deck and the leg chord, the second plate having a cut-out in an edge facing the leg chord, such that a part of the periphery of the leg chord is received within the cut-out. Still more preferably, the cut-out is elliptical

in shape.

Although sufficient strength could be provided by a single coupling plate located either above or below the shear plate, preferably, a coupling plate is provided at the top and the bottom of the shear plate. Still more preferably, the shear plate and the coupling plate are welded together.

A preferred embodiment of the invention will now be described by way of example only and with reference to the accompanying drawings in which:

Figure 1 is a side elevation of an offshore structure;

Figure 2 is a side elevation of the structure of Figure 1, showing the deck and the base in their final positions relative to the legs;

Figures 3.1 to 3.12 are a series of schematic drawings showing the construction and installation sequence of the offshore structure;

Figure 4 is a side elevation of a leg of the offshore structure, showing the arrangement of a jacking system relative to the leg;

Figure 5 is a top plan view of the offshore structure, showing the arrangement of installation guides relative to the legs of the structure;

Ins B2 ~~Figure 6 is a detail as shown at A on Figure 5~~;

Figure 7 is a plan view of a leg of the structure showing how the leg is located relative to the deck;

Figure 8 is a section through AA of Figure 7;

Figure 9 is a perspective view showing the connection made between a chord of a leg of the structure and the platform;

Figure 10 is a top plan view of the connection between a leg of the structure and the platform;

Figure 11 is a section along line 1-1 as shown in Figure 10;

Figure 12 is a detail at point A as shown in Figure 11;

Figure 13 is a detail at point B as shown in Figure 10; and

Figure 14 is a section along line 2-2 of Figure 12.

As shown in Figures 1 and 2, an offshore production platform 2 is provided having a concrete gravity base 4 of conventional construction, four triangular section lattice legs 6, and a deck 8. When installed, the gravity base 4 lies on the seabed and a permanent connection is provided between the deck 8 and the legs 6 which are arranged outboard of the deck 8, which carries conventional topsides equipment.

As is further shown in Figure 2, lifting beams 10 are provided at the top of each of the lattice legs 6. During installation a jacking system, which will be discussed later will be attached between the lifting beams 10, the deck 8 and the base 4 so that the base and deck may be raised and lowered relative to one another.

The basic steps involved in the construction and installation of the various components of the offshore structure will now be described with reference to Figures 3.1 to 3.12.

As shown in Figure 3.1, the deck 8 of the structure is constructed at an onshore site. The deck 8 is of a generally standard rectangular construction and is designed to float, which avoids the need to use separate barges when transporting the structure to the installation site as will be shown below. In particular, the deck will provide buoyancy to transport the platform from its place of fabrication to the offshore site, will assist in installing the platform at that site, refloat the platform at the end of its useful life at that site, transport it to another site, and eventually remove the platform to shore to be scrapped.

The deck 8 is then launched onto a semi-submersible barge 12 which is submerged so that the deck 8 floats off onto the water (Figures 3.2 and 3.3). The deck 8 is then towed to a fitting out quay where the topsides are

installed on the deck (see Figure 3.4).

Figures 3.5 to 3.8 show the construction and installation of the gravity base 4 and legs 6 of the structure. As shown in Figure 3.5, the legs 6 and the base 4 are constructed on shore, one of the legs 6 then being attached to each of the four corners of the base 4 in a conventional manner. A jacking system (not shown) is then assembled between the base 4 and the legs 6. In particular a plurality of strand jacks are connected between the lifting beams 10 at the tops of the legs 4 and the gravity base. The jacking system is arranged outboard of the line of the deck 8.

Next, the base 4 is launched onto a semi-submersible barge 12, the barge is submerged and the base and legs are floated off the barge. The base 4 is then sunk in the shallow water close to the shore in preparation for mating with the deck 8.

As shown in Figure 3.9, to mate the base 4 and deck 8, the deck 8 is towed between the legs 6 so that it is positioned over the base 4. As shown in Figures 5 and 6, four guide members 14 are provided on the deck 8 so as to aid in installation of the structure. Each guide member 14 is made up of a steel beam having an L-shaped recess 16 in one end thereof. The recess 16 has a hardwood facing 17 to minimise contact damage. Two of the guide members 14 at one end of the deck 8 are attached to the upper surface of the deck 8, one on either side thereof, prior to engagement of the base 4 and deck 8, so that as the deck is towed between the legs 6, it will come to rest against two legs 6 of the structure when the respective guide members 14 abut these legs 6. Thus, the guide members are used loosely to locate the deck relative to the legs 6.

Once the deck 8 is in position over the base 4, the other two guide members 14 are fixed to the deck, with the other two legs received within the recesses 16 thereof. A clearance is left between them so as to

allow for tolerances later on in the installation process. The deck 8 and base 4 are then firmly secured together by jacking the base 4 up against the deck 8. The assembly is then towed offshore to the installation site as shown in Figure 3.10.

On arrival at the installation site, the base 4 is lowered to the seabed 18 as shown in Figure 3.11 and the platform is then jacked up to the required elevation as shown in Figure 3.12. Further details of those operations will now be discussed.

The arrangement of the jacking system 21 and the guide members 14 is shown in greater detail in Figures 4 to 6. As shown in Figures 4 and 5, the jacking system 21 includes eight jacks located adjacent each of the four legs 6 of the structure. A set of four jacks 20 for lowering the base 4 relative to the deck 8 on to the seabed is provided adjacent the inner inboard corner 22 of each of the triangular lattice legs 6. Two jacks 24 for raising the deck 8 are provided between each set of base lowering jacks 22 and each leg 6, and a further two deck raising jacks 26 are provided on the other side of each of the legs 6 adjacent the deck 8. Each guide member 14 extends from the deck 8 for location, to engage the outer inboard corner 28 of each leg 6, adjacent the two further deck raising jacks 26.

Figure 4 shows the eight jacks 20,24,26 adjacent one of the legs 6 in vertical perspective view. The jacks 20,24,26 are attached to the top of the legs 6 via the lifting beam 10. They extend parallel to the leg 6 to the base 4 where they are held in a jack anchorage 30. The deck 8 located between the lifting beam 10 and base 4 is attached to each of the jacks 20,24,26 via anchor plates 23 attached to the deck 8 after the deck has been floated into position on the base 4. The deck 8 and base 4 may be raised and lowered relative to one another and to the legs 6.

As can be seen from Figures 5 and 6, as the deck is

jacked up to the required height during installation, it will be located relative to the legs 6, but with some play, by the corner 28 of each leg abutting against the guide member 14. Typically a gap of approximately 1m is left between the deck edge 32 and each of the legs 6 and about 15 cm between the legs 6 and the guide end and the legs 6.

Once the deck has been raised to the required height by the jacking system, it is necessary to form a permanent connection between the deck 8 and the legs 6 so that the jacking system may be removed. In order to do this, the deck 8 is first more accurately located relative to the legs 6.

The means of locating the deck relative to the legs 6 are shown in Figures 7 and 8. As shown in Figure 7, each lattice leg 6 is triangular in shape and has a vertically extending chord 34 at each of its three corners. Two of the three corners of each triangular leg are arranged adjacent the deck edge 32. Thus, the third corner of the leg (referred to as the outboard chord) is positioned further outboard with respect to the deck 8.

To locate the deck, a strop 36 is attached around the outboard chord 34. A hydraulic tugger 38 is then attached between the strop and a padeye 40 provided at the bottom 42 of the deck edge 32. In addition, a pair of inwardly inclided hydraulic screw jacks 44 are positioned between fixed deck brackets 41 extending from the bottom 42 of the deck edge 32 and each of the inboard tubular members 34. The hydraulic tugger 38 is then tensioned so as to pull the respective leg 6 towards the deck 6 and, more specifically, the relevant chord 34 of the leg 6 against the guide member 14.

Next, the screw jacks 44 are activated to seat between the deck brackets 41 and the tubular members 34 and the hydraulic tugger 38 is tensioned further so as to hold the connection in position. As the guide

members 14 are positioned at the top surface of the deck 8 and the screw jacks at the bottom of the deck 8, the temporary connection formed to locate the deck relative to the legs 6, provides a relatively accurate means of location in both the horizontal and vertical planes.

After the deck has been located relative to the legs 6 as described above, a permanent connection is then formed between the deck and the legs 6. A schematic perspective view of the connection between an inboard chord 34 of a leg 6 and the deck edge 32 is shown in Figure 9. The connection is made up of a vertically extending steel shear plate 46 and upper 48 and lower 50 horizontally extending metal coupling plates. The connection is shown in greater detail in Figures 10 to 13. As shown in Figure 10, respective connections are made between each of the two inboard chords 34 of the leg and the deck edge 32.

One end of the shear plate 46 is butt welded to one end of a stiffening plate 52 which extends through the diameter of each of the inboard chords 34 to which a connection is to be made (see Figure 12). When making the connection, the shear plate 46 is firstly swung into position between a chord 34 and the deck edge 32. This plate 46 is then butt welded to the stiffening plate 52 along one of its outboard vertical edges. In order to allow for a degree of tolerance in vertical alignment between the legs and deck, the stiffening plate 52 extends over a greater length L_1 of the chord 34 than the length L_2 of the shear plate 46 to which it is welded. Indeed the stiffening plate extends upwardly as far as the lifting beam 10 in each leg 6.

The shear plate 46 is then attached to the platform edge as follows.

As shown in Figure 14, a first metal plate 54 is fillet welded to the deck edge 32 so that it extends out from the deck adjacent one side of the shear plate 46.

A second metal plate 56 is then fillet welded to the deck edge 32 so that it extends adjacent the other side of the shear plate 46. The shear plate 46 is then fillet welded to both of the metal plates 54 and 56. This method of attachment means that the width of the shear plate 46 need not be exactly the same as the distance between the stiffening plate 52 and the deck edge, thereby providing a tolerance in the horizontal positioning of the deck 8 relative to the legs 6.

Once the shear plate 46 has been welded into position, the upper 48 and lower 50 coupling plates are then swung into position. The coupling plates 48,50 are formed with an elliptical cut-out 58 in their outboard edges, as shown in Figures 10 and 13, and each chord is received in a cut-out 58. As the cut-out 58 is elliptical rather than circular, in shape, some degree of angular tolerance is provided in the positioning of the coupling plate 48,50 relative to the chord 34. As can be seen from Figure 13, web 60 extends outwardly from the upper surface 62 of the deck edge 32. Location brackets 63 are pre-welded to the deck 8 and the web 60 so as to assist in alignment of the upper coupling plate 48,50 with the web 60. The coupling plate is then cut to size so as to fit between the web 60 and the chord. One end of the coupling plate 48,50 is positioned against the end of the web 60 and butt welded to the web, while the other end of the coupling 48,50 is butt welded to the chord 34 around the circumference of the cut-out 58. The coupling plates 48,50 are also fillet welded to the shear plate 46. Thus, again, tolerance is allowed in the horizontal distance between the leg and platform. Plate stiffeners 64 are also welded across the coupling plates 48 and 50 and their respective webs 60.

The connection between the deck 8 and each leg chord 34 thus comprises a shear plate 46, and two coupling plates 48,50, and this provides a strong

connection capable of withstanding both shear and bending loads.

Once a connection as described above has been made between the two chords 34 of each leg 6 and the deck 8, the jacking system may then be removed.

It will be appreciated by those skilled in the art that many modifications could be made to the embodiment of the invention described above without departing from the scope of the invention as claimed. Thus, the platform may have any number of legs and those legs could be of any shape, for example, they could be square. Furthermore, the invention may also be applicable to structures having legs which do not have a lattice structure.